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AUTHOR Colagrande, John; Santarsiero, Thomas
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ABSTRACT

Material for this teacher's guide include: (1) an introduction to the unit; (2) a discussion of the sections of the unit; (3) instructional objectives; (4) suggestions on use of filmstrips, worksheets, reference materials, and activity cards; and (5) an outline of the unit. These materials have been validated as successful, cost-effective, and exportable by the standards and guidelines of the U.S. Office of Education. (RH)

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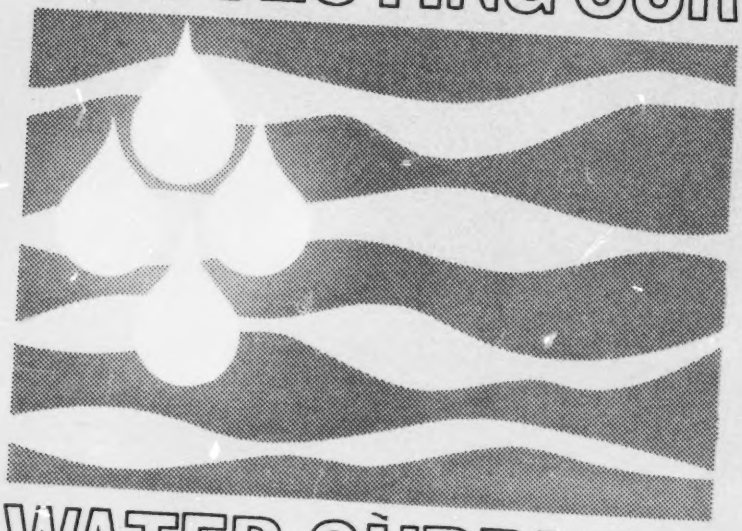
PRIORITY ONE
ENVIRONMENT

PROTECTING OUR



WATER SUPPLIES

SE 021 902

PRIORITY ONE
ENVIRONMENT

POLLUTION CONTROL EDUCATION CENTER
Township of Union Public Schools
Union, New Jersey

PROTECTING OUR WATER SUPPLIES

Project Director	**Charles Murphy**
Art Director	**Milton Knobler**
Production Coordinator	**Patricia McCutcheon**
Authors:	John Colagrande Thomas Santarsiero
Contributing Writers:	Joseph Caliguire Grace Forke Patricia McCutcheon Rocco Siravo
Teacher's Guide:	John Colagrande Patricia McCutcheon
Graphics and Design:	Milton Knobler
Photography:	John Colagrande Charles Murphy
Compositor:	Joan Wirth
Technical Consultants:	Florence Porcello, Statistical Analysis William Wishart, Graver Water Division, Ecodyne Company
Superintendent of Schools:	Robert Fleischer
Title III Coordinator:	James Caulfield
New Jersey State Department of Education Office of Program Development:	Robert Ward Evelyn Ogden

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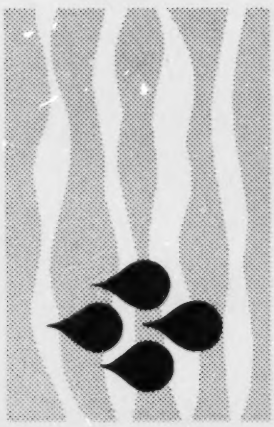
PROTECTING OUR WATER SUPPLIES



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INTRODUCTION TO THE UNIT
PROTECTING OUR WATER SUPPLIES

We, as typical Americans, use large quantities of clean water, and produce large quantities of dirty water. We dirty water directly and indirectly by using many products that require clean water in their manufacture. We are a nation of steel. We have cars of steel, appliances of steel, and our buildings have steel skeletons. The production of steel consumes enormous quantities of clean water. We are also a nation of paper. We have books, tissues, newspapers, paper plates, and hundreds of other products made of paper. Paper production also requires large amounts of clean water.

Steel and paper are just two of many industries which use clean water. In fact, industry uses more than five times the amount of clean water used directly by people in their homes and offices. This used water contains chemicals and debris, introduced by man. Chemicals and debris can be harmful to plants and animals and, therefore, the water is said to be polluted. As our country's population grows, its demand for clean water will increase as clean water becomes scarcer.

The Guide provides you with methods and suggestions that will help you coordinate the components of this unit into a meaningful sequence of events for your class. The unit is composed of five sections; under the heading **Making the Materials Work, Suggestions for the Teacher**, you will observe that we have presented a treatment of the components to be used in a section in the same sequence that we suggest you use them. We recommend that you use the suggested sequence the first time you teach the unit and make any variations thereafter which you prefer.

We have field-tested **Protecting Our Water Supplies** and represent it as a two week instructional unit which can be used daily for about ten class hours. However, it is flexible enough for you to make whatever adaptations best suit your local class scheduling. In order for the three experiments which the class will set up during or before Section I to be ready for interpretation in Section III, you should remember to: set up for Worksheet 1 ten days prior to Section III, set up for Worksheet 2 five days prior to Section III, and set up for Worksheet 3 at any convenient time that is at least one day prior to Section III.

Section I — **Water Use and Abuse** introduces the students to the many ways that water is used and abused by Americans and provides for the setting up of three pollution-monitoring experiments.

Section II — **Pollution: Causes and Some Effects** examines water pollution as a combination of these four factors—political, economic, social, and technological—which are called the PEST factors.

Section III — **Pollution: Interpreting Your Experiments** enables the students to evaluate the data they have collected concerning three of the pollutants of our water supplies—phosphates and nitrates, soaps and detergents, and sewage.

Section IV — **Protection: Technology at Work** informs students how clean water can be preserved and how waste water can be treated in order to prevent pollution of our water supplies.

Section V — **Protection: It's Everybody's Job!** structures a role-playing experience in community water-protection planning and provides for evaluation of the water supply and the water quality of the students' own community.

INSTRUCTIONAL OBJECTIVES

The developers of *Priority One: Environment* have recognized student input as essential to structuring significant learning experiences. The materials in this unit, *Protecting Our Water Supplies*, have been student and teacher-tested in the development stages. The educational objectives of the unit, as specified below, are correlated with a twenty-question multiple-choice test. It has been provided for your use on two of the Eco-masters. Answers to the test appear on page 24 of this Guide.

We recommend that you administer the unit test to each of your students before and after using this unit so that you can measure the growth in learning that the field-testing of each *Priority One* unit has shown to take place. Further inquiry concerning evaluation procedures and designs can be made directly to the **Pollution Control Education Center, Union Township Board of Education, Union, New Jersey.**

At the end of this unit, the student will be able to:

1. Expand a list of water uses to include the use of water for generating electricity, for irrigation, and for food processing.
2. State three causes for the escalating demand for clean water.
3. Predict the future availability of clean water.
4. Read a water meter.
5. Compute the amount of water used in his own home.
6. Utilize research material and resource personnel outside the classroom in order to answer questions about water quality in the local and state environment.
7. Cite three examples of each of these factors of water pollution—the political factor, the economic factor, the sociological factor, and the technological factor.
8. Derive an itemizing of the P–E–S–T factors from data given on "Riverview," a watershed community.

9. Sample both attitudes and general information in his own community concerning water pollution.

10. Replicate the procedures of setting up three laboratory experiments on water pollution—on eutrophication, on bacterial contamination of water, and on the effects of detergents and soaps on water.

11. Identify the specific pollutants involved in each of the experiments and to describe how each pollutant produced the observed changes in the water during the process of experiment.

12. Describe the operation of a food chain in an unpolluted waterway.

13. Identify the four most common pollutants of waterways as—sewage, bacteria, nutrients, and debris such as silt and sand.

14. Give at least four examples of disease that can be incurred by contact with polluted water.

15. Name and describe the 3 types of sewage treatment—primary, secondary, and tertiary.

16. Describe what is involved in regional planning for water quality, citing Lake Tahoe as an example.

17. Evaluate current water pollution control technologies in terms of efficiency and economy.

18. Describe the function of the Environmental Protection Agency in regulating pollutant discharges.

19. Identify the 2 major federal programs concerned with water quality control.

20. Cite at least 5 ways in which he as a citizen can help to make our water supplies clean.

SECTION I WATER USE AND ABUSE

FOCUS

In this first section of the unit, the students will discover and evaluate the many ways water is used and abused by Americans. Depending on whose figures you believe, the average American uses between 45 and 100 gallons of water a day. Our capacity to pollute has outstripped our ability to provide good waste water treatment at costs we seem to be willing to pay. Also, in this section the students will set up experiments which will demonstrate: how nutrients affect the growth of pond algae, the effect of sewage on microorganisms, and how common household pollutants—soaps and detergents—react with water microbes.

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
Preface to the Unit	**Filmstrip 1** Water, The Abused Servant of Man **Audio Cassette, Side A** **Overhead Transparency** Water Use	**Worksheet 1** The Effect of Phosphates and Nitrates on Pond Algae **Worksheet 2** How Microorganisms in Water React to Soaps and Detergents **Worksheet 3** The Effect of Sewage on Microorganisms	**Activity Card 1** Water Use in the Home

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Worksheet 1 — The Effect of Phosphates and Nitrates on Pond Algae

Raw sewage and land runoff may contain quantities of phosphates and nitrates. When these chemicals enter a waterway in sufficient quantities, they cause the bacteria and the algae and other water plants to grow and reproduce at an accelerated rate. This growth can precipitate a premature aging of the waterway called *eutrophication*.

Read Worksheet 1. The materials listed are for each student or student team. Decide whether you wish your students to run this experiment individually, in groups, or as a class. However you decide, each student should have a copy of the worksheet.

Make certain that your students carefully record the concentrations of nutrients as the experiment is set up. Set aside some time from each of the 10 subsequent days for the students to add additional pollutant mixture (nutrient) to the samples and to make and record their observations.

The water samples used should be collected from a pond which is relatively unpolluted and one which you know will probably contain microorganisms.

Worksheet 2 – How Microorganisms in Water React to Soaps and Detergents

Soaps and detergents represent common household pollutants. This experiment demonstrates that some soaps and detergents are less biodegradable than others.

Read Worksheet 2. The materials listed are for each student or student team. Since the materials for this experiment are easily obtainable, it is recommended that every student do the activity either as a member of a pair or individually. However you decide, each student should have a copy of the worksheet.

The amount of soap or detergent in the sample can be determined by comparing the relative height of the suds formed when the jar is shaken. Set aside some time on each of the subsequent days for the students to shake the containers, observe the suds level, and to record their observations. Remind them to loosen the lids of the jars.

Worksheet 3 – The Effects of Sewage on Microorganisms

Working with real raw sewage and bacteria is not recommended. This experiment will give the same results without health risks and the results are rapid and dramatic.

Read Worksheet 3. The materials listed are for each student or student team. Again, you may structure the grouping for this activity in any way that you wish, but each student should have a copy of the worksheet. Be sure to have the students note the original colors in each of the test tubes before they are set in a warm, dark place to incubate.

Overhead Transparency – Water Use This overhead transparency encourages the students to identify and list the ways that water is used by people and industry. It lists six water use headings. You may give the students about ten minutes to copy the transparency and fill-in as many uses as they can under each heading. Have the students work individually or in pairs.

Filmstrip/Audio Cassette – Water, The Abused Servant of Man Show the filmstrip to the class and have them add any examples of water use they did not think of prior to viewing the filmstrip. Ask the students to retain their lists for use later in the unit.

To conclude the lesson, make these points:

1. Everyone, regardless of age, uses water directly. You may wish to mention that we use 3 gallons each time the toilet is flushed; 35 gallons for a bath; 20 gallons in the washing machine; 10 gallons to wash dishes by hand; and varying amounts on gardening, house cleaning, and drinking.

2. Everyone uses water indirectly. Our standard of living requires products and services which require clean water and produce polluted water.

CHART: Water use in billions of gallons per day

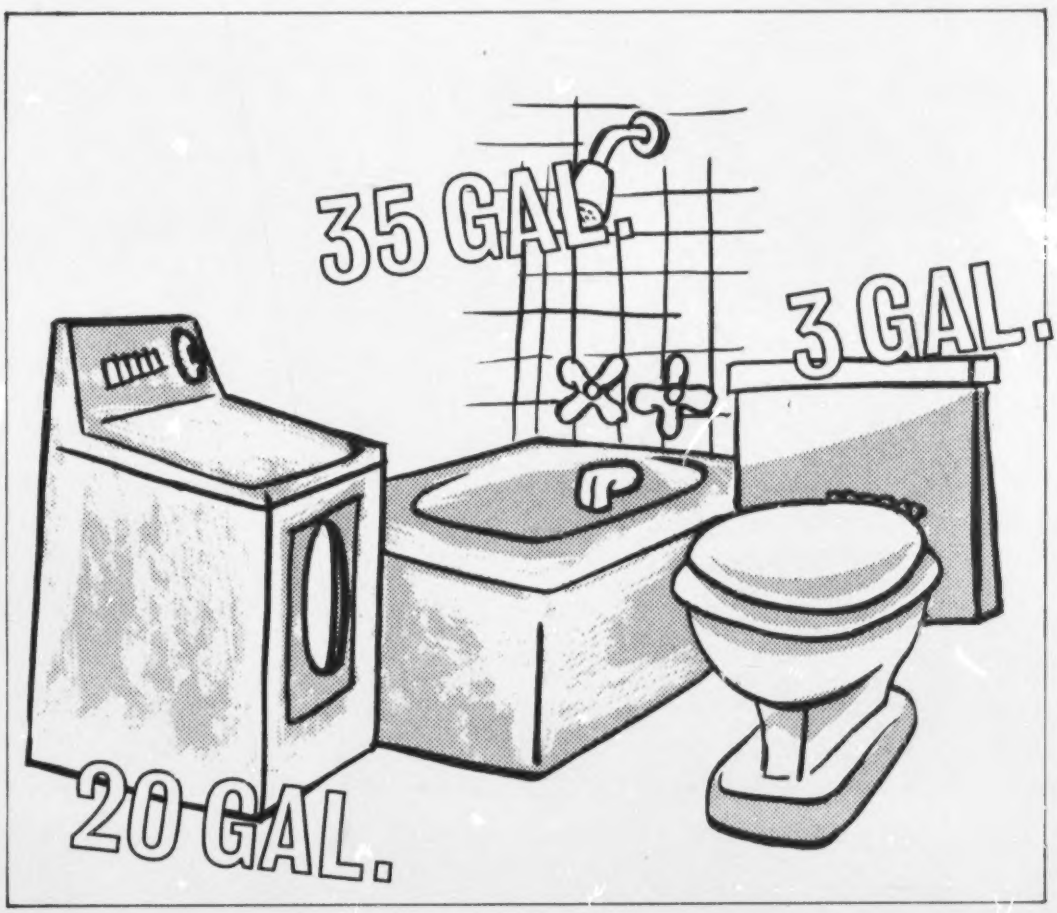
	1950	1960	1970	1980	2000
Municipal	14	21	25	29	42
Industrial	77	140	250	363	662
Agriculture	83	114	143	167	184

3. As the population of this country increases, water consumption will increase also. Demands for clean water will increase, but not the available supply. Some experts estimate that by 1980 the demands for clean water will have exceeded the supply. We must learn to use the water we have wisely, to clean up what we have polluted, and then to keep it clean.

Before we can discuss the technology of clean up, we must first examine the causes of water pollution. Your students will be led to identify the four factors which can lead to water pollution in the next section.

Activity Card 1 – Water Use in the Home: How Much and for what Purpose?

This activity should be suggested after the filmstrip, "Water, The Abused Servant of Man," has been shown. It allows the student to determine quantitatively the daily water needs of typical American families. It is recommended that students who do this activity take readings daily throughout the unit, and average their totals on a person-per-day basis later.



SECTION II POLLUTION: CAUSES AND SOME EFFECTS

FOCUS

Before the topic of water clean up technology can be introduced, the students should first identify water pollution causes. In this section, the students will examine some of the causes of water pollution and see these causes as a combination of four factors. This is accomplished by taking these two steps:

1. First the students formulate an hypothesis, specifically: *Water pollution is caused by a combination of four factors. They are political, economic, social, and technological.* This hypothesis will evolve from their homework assignment entitled, "Water Pollution Inquiry."

2. Then the students will test the hypothesis by investigating a fictitious town called Riverview. Their investigation will prove the hypothesis.

The Riverview material provides input on how to investigate water pollution in a given area. It teaches the students what to look for, where to look for it, and how to organize their findings, or *data*.

After the Riverview experience, the students will probably be eager to investigate the quality of their own environment. This section culminates, therefore, with a student-oriented investigation of the local community designed to answer questions such as:

1. What is the availability of water in your area?
2. Is there polluted water in your area?
3. Is waste water treated in your area? If so, how?
4. Are there any provisions made for water pollution prevention in your area? If so, what are they?

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
Riverview	**Blank Overhead Transparencies**	**Worksheet 4** Water Pollution Inquiry Questions **Worksheet 5** Water Pollution Inquiry Answer Sheet **Worksheet 6** Analyzing Riverview **Worksheet 7** Investigating Your Own Community	**Activity Card 2** Water Pollution Opinion Poll

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Worksheet 4 – Water Pollution Inquiry

Divide the class into four groups, A, B, C, and D. Hand out copies of the worksheet and instruct each student to answer each question assigned to his group for homework. These answers should be in complete sentences so that the student need not reread the questions. A student should feel free to use any source that helps him answer the questions, such as books, newspapers, maps, encyclopedias, someone at home, or someone at city hall. It may be a little difficult for some of the students in your region to answer a particular question assigned to their group. Read through the students' material and try to anticipate possible problem questions. You will find it helpful to have the answers ready, should all the students in one group fail to answer a particular question.

Worksheet 5 – Water Pollution Inquiry Answer Sheet

Hand out copies of this worksheet the day after the students complete Worksheet 4. Ask the students in Group A to answer Question 1. Summarize, and instruct everyone to record the summary on Worksheet 5. You might also like to use a blank overhead transparency to record the summaries.

Then summarize and record Group B's answer to their Question 1. Record it under Group A's answer on Worksheet 5 and on the overhead transparency. Repeat for Question 1 from Group C and Group D. Summarize and record the answers to Question 2 of each group on Worksheet 5 and on a second overhead transparency. Do the same for Questions 3 and 4.

Question 1 of each group identifies a political factor of water pollution. Question 2 of each group identifies an economic factor of water pollution. Questions 3 and 4 identify social and technological factors respectively. Do not mention this to the students yet.

After the answers to all 16 questions have been summarized and recorded by you on the overhead transparency and by the students on Worksheet 5, ask the students to identify the names of the four factors of water pollution: Political, Economic, Social, and Technological (PEST). Explain to the students that the identification of the PEST factors represents a tentative hypothesis which must be tested before it is accepted.

Booklet Article – Riverview

Explain to the students that they will now visit a polluted waterway, examine it, and collect data about it. They will also determine whether the information that they obtain can be categorized in the PEST groupings. If so, their inquiry will have confirmed the hypothesis, that water pollution is a combination of political, economic, social, and technological factors.

The Riverview materials have been divided into three groups:

1. Four photographs taken by a vacationing family.
2. Six articles from the *Riverview Gazette*.
3. The answers to a questionnaire distributed by two seventh grade students as a social studies assignment.

Ask the students how they could investigate a place if they could not visit there themselves. What alternate sources of information would they accept in lieu of an actual visit? Record their answers on the chalkboard until photographs, newspapers, and interviews have been mentioned and recorded. Accept all responses, then zero in on these three and discuss briefly what kind of information each of these three could potentially supply. After these sources have been discussed, hand out the booklets so the students can examine Riverview.

These materials have been written to indicate various aspects of water pollution. Some indications are quite obvious; others are subtle.

Source of Information	Obvious Indication	Subtle Indication
Photographs	Debris on beach and in the water.	a. bulldozer in background of photograph 2. b. conduit in background of photograph 3.
Newspaper	Eye infection of John D.	a. smaller fish caught by Jimmy J. and Kathy C. b. algae growth mentioned in Sandy R's essay.
Questionnaire	Ms. S's comment "The water smells when it's hot out."	a. poor taste of well water. b. septic tank seepage into river.

Worksheet 6 – Analyzing Riverview

When the students have finished reading Riverview, distribute the worksheet and have the students answer the questions.

Question 1 through 8 are designed to:

1. Motivate the student to reread significant parts of the materials.
2. Demonstrate how some people feel about water pollution.
3. Foster discussion among students so they can express their own attitudes about water pollution.

Questions 9 and 10 demonstrate the importance of regional planning and cooperation between communities to correct and prevent water pollution.

Drawing Conclusions allows the students to prove their hypothesis from Section I – water pollution is a combination of the four **PEST** factors.

Even though the town of Riverview, along Emanon River, is not a real place, the problems which your students identified there are very real to many people in many real places.

Ask the students how their community compares with Riverview. From where does their community get its drinking water? Where does their community

dump its sewage? Is the sewage treated first? How? Is their community growing? Will the water supply meet future needs?

If the students fail to answer these questions, or answer them incorrectly, explain to them that some day their community and its water supply will be theirs to govern as voters. Explain to them that they should know the condition of their community's water supply now and what its condition might be when they are homeowners and taxpayers.

Worksheet 7 — Investigating Your Own Community

In order to lighten the students' task and give them some direction, hand out the worksheets. Let the students read both worksheets carefully. You may ask them which questions they would like to answer, or you may direct certain students toward certain questions. Some questions may require that only one student work on them, such as:

1. Construct a map of the county in which your community is situated.

3. Contact the water company which serves your community.

Other questions may require that a group of students work on them, such as:

4. Visit waterways in your community and look for signs of pollution.

8. Contact several local industries which might be potential water polluters.

The answers to the questions should be written in full sentences so that the students need not refer to the worksheets when the assignment is complete. Some of the questions will take several days to answer. It is therefore recommended that the students present their answers or describe their findings to the class in the final section of the unit.

Activity Card 2 -- Water Pollution Opinion Poll

Two students in Riverview conducted a survey as an assignment for their social studies class. This survey was not specifically designed for water pollution, but it did turn up some attitudes and feelings about water pollution. Some of your students may wish to conduct their own survey on water pollution in their own community. This activity card will give these interested students direction and some suggestions for conducting such a poll.

SECTION III POLLUTION: INTERPRETING YOUR EXPERIMENTS

FOCUS

In this section the students will make their final observations on the experiments started earlier. They will learn that excessive amounts of phosphates and nitrates introduced into a waterway can cause the algae in the waterway to grow and reproduce at an accelerated rate. This rapid growth is called an *algal bloom*. Students will identify the effects which sewage has on microorganisms in a waterway. They will learn that a moderate number of microorganisms is beneficial, but an excessive amount can cause oxygen depletion so extensive that animals that live in the waterway will die. The students will also learn that pure soaps are biodegradable, that germicidal (deodorant) soaps can kill helpful microorganisms in a waterway, and that many detergents are essentially not biodegradable.

The effects that pollutants can have on a waterway ecosystem are outlined in the two booklet articles, "A Healthy Waterway" and "An Unhealthy Waterway." The overhead transparencies for use with the articles help explain the process of photosynthesis and the role that aerobic bacteria have in a water environment.

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
A Healthy Waterway	**3 Blank Overhead Transparencies**		**Activity Card 3** Water-borne Diseases
An Unhealthy Waterway	**Overhead Transparencies** Life in a Healthy Waterway Life in an Unhealthy Waterway		**Activity Card 4** Succession on a Microscope Slide
			Activity Card 5 The Effect of Dissolved Salt on Aquatic Plants

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Review with your students the procedures they used for setting up the experiments. You may want to refer to Worksheets 1, 2, and 3 to review how the experiments were monitored and the schedule of monitoring which the students followed. Have the students make the final observations, record them, and encourage the students to summarize their results in one or two sentences. Itemized below are the conclusions, or summaries, to be reached.

Worksheet 1 – The pond water sample which received the largest amount of pollutant (nutrient) should be noticeably greener than the sample into which a moderate amount was introduced. This sample, in turn, should be greener than the control, which contained no pollutant. The students should conclude that the addition of phosphates and nitrates to a healthy waterway will cause the algae there to grow and reproduce at an abnormal rate.

Worksheet 2 – The water sample with the nongermicidal soap should have the lowest level of suds of the three samples. The microorganisms in the pond water were able to digest (degrade) the soap molecules.

The chemical in the germicidal soap which stops perspiration odor killed many of the microorganisms in the second jar. The few microorganisms which were left could degrade fewer soap molecules, so there were more suds in the second jar than in the first. The level of suds in the third jar remained the highest because detergents are essentially non-biodegradable.

The students should conclude that excessive amounts of germicidal soaps and detergents dumped into a stream or river will cause unsightly suds to form.

Worksheet 3 – The 1 percent milk (sewage) solution should be deep blue. This indicates the presence of much oxygen, therefore a low level of activity on the part of the yeast. The blue color should become fainter as the concentration of milk increases. This loss of color indicates a reduction in the amount of oxygen. This reduction is caused by an increase both in the numbers and the activity of the yeast cells.

The students should conclude that an excessive amount of sewage in a waterway may lead to an oxygen depletion in that waterway. This depletion is brought about by the increased activity of microorganisms.

Blank Overhead Transparencies Having completed the three experiments, your students are now ready to describe their results. Take the three blank overhead transparencies and, on the left side of each, write **Pollutant**. Under the word **Pollutant**, write **nitrates/phosphates** on the first transparency; **soaps/detergents** on the second; and **sewage** on the third. Each transparency should have three columns, as the example below illustrates.

Pollutant	**Entrance**	**Change**
nitrates/phosphates		

Have your students answer for each pollutant, "How could this pollutant enter a waterway?" and "How does this pollutant change the waterway?" Summarize their responses and write them in the appropriate column on each transparency. You might like to have the students make and keep a copy of their answers for their notebooks. The list could be further expanded, if you wish, as the students learn about other pollutants in the course of this unit.

Booklet Article and Overhead Transparency – A Healthy Waterway

Now you might want the students to read the article which stresses that there are various cycles within a waterway which allow the water to purify itself. The cycles are: **hydrologic, food/waste,** and **oxygen/carbon dioxide**. They are explained further by the accompanying overhead transparency.

Show the overhead transparency and ask the following suggested questions to determine the students' understanding of what they have read and what they are seeing.

1. What causes evaporation?
2. What causes precipitation?
3. What is photosynthesis?
4. How does the fish benefit from photosynthesis?
5. What part does the snail play?
6. What part do the aerobic bacteria play?
7. Why is the bottom clean and the water clear?
8. If aerobic bacteria need oxygen, what are anaerobic bacteria?
9. What becomes of normal runoff from the land?

Booklet Article and Overhead Transparency — An Unhealthy Waterway

Next the students should read about the kinds of human-caused pollutants. To determine whether they understand what they have read, have them close their booklets and help you complete the overhead transparency which you will show next.

Notice that there are no arrows on this overhead transparency and that the insets labeled **Algae**, **Aerobic Bacteria**, and **Anaerobic Bacteria** are blank. You can fill these in as you explain exactly what happens when a specific pollutant is allowed to enter a waterway in great amounts. The pollutant is excessive nutrient material (nitrates and phosphates) from farm runoff, or sewage, or both.

With an erasible marker, draw an arrow from **Excessive Human-Caused Pollutants** to the inset labeled **Algae**. Explain that nitrates and phosphates are fertilizers and that an excess can cause an algal bloom. Fill in the **Algae** inset with many dots. This bloom will cause an increase in oxygen which will stimulate the growth of aerobic bacteria.

Draw an arrow from **Algae** to the inset labeled **Aerobic Bacteria**. Label the arrow **Excess Oxygen**. Fill in the **Aerobic Bacteria** inset with dots. These bacteria reproduce at a tremendous rate (more dots) and eventually use up most of the available oxygen, causing the death of the fish and the snail. As the aerobic bacteria continue to multiply (more dots), they use up all of the available oxygen, causing their own deaths and the death of the algae. Erase the arrow labeled **Excess Oxygen**. Then smear, but do not erase fully, the insets labeled **Algae** and **Aerobic Bacteria**. These organisms are dead, but have not been decomposed as yet. At this point the anaerobic bacteria, which have been lying dormant, become active and start decomposing the dead algae, aerobic bacteria, the snail, and the fish. Fill in the inset labeled **Anaerobic Bacteria** with dots. The activity of the anaerobic bacteria causes the discoloration and smell associated with many of our waterways (more dots). Fill in the water with streaks to indicate discoloration and draw wavy arrows coming off the water to indicate smell.

Activity Card 3 — Water-borne Diseases

After the booklet article, "Life in an Unhealthy Waterway," some students might wish to do additional research into some of the health problems incurred when people come into contact with water contaminated by untreated human waste. This activity identifies for the students some diseases which are spread by water.

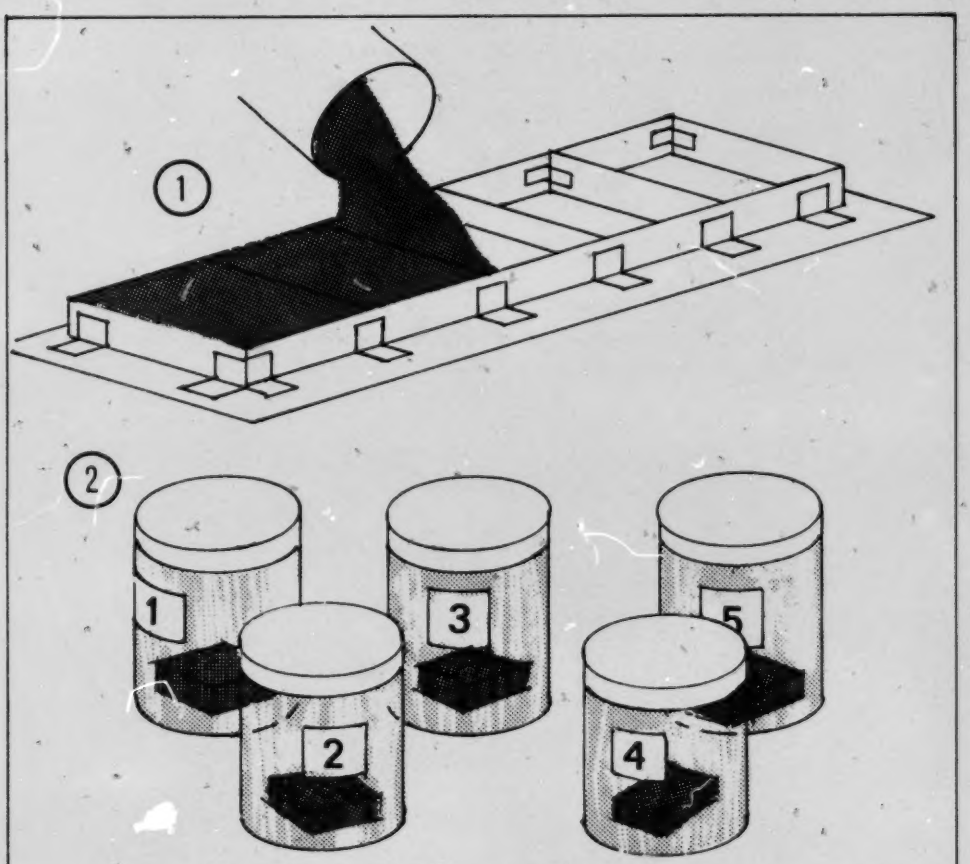
Activity Card 4 – Succession on a Microscope Slide

This activity should be introduced after the class discussion of "Life in a Healthy Waterway." It requires the use of a microscope and a sample of pond water. The pond water sample should include bottom material and some of the scum which coats the rocks in the pond. If pond water is unavailable, a sample may be obtained from the white filter material in an outside aquarium filter.

Activity Card 5 – The Effect of Dissolved Salt on Aquatic Plants

This activity will give good results in a few days. It should be introduced after "Life in an Unhealthy Waterway" is covered in class. An additional long range demonstration may be started and observations made on a yearly basis. This demonstration is on the effects of dissolved salts on concrete.

Obtain ready mixed concrete or mortar. Follow the directions on the bag and cast five slabs of concrete to measure 2" x 2" x ½". Place a slab of concrete into each of the five jars, as shown below. Fill each jar with one of the five solutions. As the concrete in the salt water deteriorates, you will be able to have subsequent students in your classes observe the effects that salt has on concrete sidewalks, road surfaces, foundations, and bridge supports throughout the years.



USE THE FIVE SOLUTIONS DESCRIBED IN ACTIVITY CARD 5.

SECTION IV PROTECTION: TECHNOLOGY AT WORK

FOCUS

In this section the students will learn what can be done to waste water to prevent pollution of the water cycle. They will learn about tertiary water treatment, what it is, how it works, and how well it works. The students will duplicate a step taken at some tertiary water treatment facilities—the removal of the phosphates from the sewage water. This section will also describe certain other kinds of pollutants which are proving particularly difficult to control. These special pollutants are usually localized and, in some cases, occur only sporadically.

At this point in the unit, the students have learned how to recognize water pollution and about its causes, sources, and effects on the environment. The citizens of the Lake Tahoe region of California and Nevada went through these same learning stages. Water pollution threatened the area's recreation and vacation industry. The residents of the Lake Tahoe region joined forces to correct their water pollution problem and thereby to preserve one of the most beautiful places in the United States. The technological solution which they chose is tertiary treatment. Thus, we have a real story with a happy ending.

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
Cleanup Technology **Effects of Certain Other Pollutants** **Lake Tahoe**	**Overhead Transparency** An Ideal Tertiary Sewage Treatment Plant **Filmstrip 2** Lake Tahoe—Then and Now	**Worksheet 8** Removing Phosphates from Sewage Water	**Activity Card 6** Carbon Absorption **Activity Card 7** Constructing a Tertiary Sewage Treatment Plant

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Booklet Article — Cleanup Technology

Have the students read this article, which describes briefly how nature can purify water, provided that the water is not too badly polluted. The hydrologic cycle is given as an example of how this can be done. You may want to point out to the students that nature's water cycle is like a large distillation apparatus. You may also wish to describe another way nature cleans water. The water in a stream, moving over waterfalls and through rapids, picks up oxygen. Rocks on the bottom of the stream are covered with a film. Within this film are bacteria, protozoa, and fungi. These organisms, in the presence of oxygen, can decompose organic materials in the stream's water. Silt, sand, and other debris settle out of the stream when it enters a lake or pond. Here the water flow is slowed down and the suspended particles have a chance to settle out. The lake or pond

will be flushed out every year during the spring runoff. Description of the three steps which may be used to purify waste water before returning it to nature are given in the article. After the students have read the article, explain to them that man, in his attempt to treat waste water, has simply extended natural processes as mentioned above.

Overhead Transparency – An Ideal Tertiary Sewage Treatment Plant Show this overhead and determine whether the students can identify and describe the stages of sewage treatment without using their booklets. You can ask questions such as the following:

1. What happens in a grit chamber?
2. Why is the water chlorinated before it is discharged?
3. How does a carbon absorption chamber work?
4. Where, on the transparency, does primary treatment end? Secondary treatment?

If you have an aquarium in your classroom, you can describe its filtration system in terms of a water treatment plant (which it is). If your aquarium has no filter or aeration system, it is an example of a primary treatment facility. The solid wastes settle out into the gravel (sedimentation). The decomposition of the sludge is minimal due to the low number of aerobic bacteria. The gravel must be cleaned frequently because of this, and no provisions are made for dissolved wastes. If your aquarium has an undergravel filter, it is an example of a secondary treatment plant (sedimentation, aeration, and trickling filter). The filter sets up a current which draws the water and waste through the gravel on the bottom of the tank. The apparatus which sets up this current also oxygenates the water so bacteria in the gravel can digest the waste. However, still no provisions are made for dissolved wastes. If your aquarium has an outside filter, then it is an example of a tertiary treatment facility (sedimentation, trickling filter, aeration, and carbon absorption). The filter draws the water in, trapping the solid wastes in the white filter material, where they decompose. The activated charcoal underneath absorbs most of the dissolved organic materials. As in the larger tertiary treatment plants, the charcoal can be reactivated by heat.

The student booklet contains no information about what happens to the sludge or waste residue. If the question comes up, explain that some sewage treatment plants process the sludge in a chamber called a digestor. Here, bacteria work on whatever nutrients are present. After the bacteria have exhausted the nutrients, the sludge is dried out in sludge beds and used as landfill. While bacteria decompose the sludge, they produce gases. These gases are flammable and can be burned to help dry out the processed sludge in the beds. In other facilities, the sludge is held in shallow lagoons, mixed with air, and used for fertilizer. In still other operations, it is loaded into barges and dumped at sea.

Worksheet 8 – Removing Phosphates from Sewage Water

This worksheet provides for one of the processes of tertiary water treatment to be simulated. Prepare a sample of *polluted* water by dissolving some potassium phosphate into distilled water. Each student team will need 100 ml of this polluted water, so be sure to prepare enough. To save time, you might also wish to prepare the calcium hydroxide solution ahead of time. Calcium hydroxide is only slightly soluble in water (0.17g/100 ml) and the filtering of this solution takes time.

Hand out Worksheet 8. Have the students read the directions and questions before starting the experiment.

When the two solutions are combined, the calcium will attach to the phosphate and precipitate calcium phosphate. The potassium hydroxide will remain in solution. The calcium phosphate may be filtered out and, if there is time, more calcium hydroxide may be added to the filtrate in order to determine whether all of the phosphates have been removed. You might point out to the students that this process can be expensive in areas where phosphates are dumped in large quantities. However, in such areas there seems to be no technological alternative.

Booklet Article – Effects of Certain Other Pollutants

If the students want to learn about other pollutants, you can have them read this article. They can also expand the chart they made for Section III to include these other pollutants which tend to be introduced into waterways intermittently from specific point sources.

Filmstrip – Lake Tahoe, Then and Now Another description of the tertiary water treatment process is contained in this filmstrip, and it should be shown at this time. It serves as a review for "Cleanup Technology" and is a true pollution story with a happy ending. Encourage your students to discuss these questions on the last frame.

1. What was the ultimate cause of the water pollution at Lake Tahoe?
2. On what is the economy of the Tahoe Basin dependent?
3. What type of water treatment facility do they have at Tahoe?
4. Where is Lake Tahoe?

Have the students answer all four questions orally. Write the answers on the chalkboard in full sentences. The answers to Questions 1 and 2 show that people were causing the pollution of an area where tourism was the main industry. This was quite a dilemma!

The answer to Question 3 shows how the pollution problem was solved at Tahoe. The answer to Question 4 demonstrates another problem. Lake Tahoe lies in two states. Getting things done within a state is one problem; getting things done in two states at the same time is even a greater problem. California and Nevada provided an example of the success of regional planning through the effectiveness of their Tahoe Regional Planning Agency.

For more information on problems of regional cooperation and how they were solved, have the students read the Lake Tahoe article in their Resource Booklets.

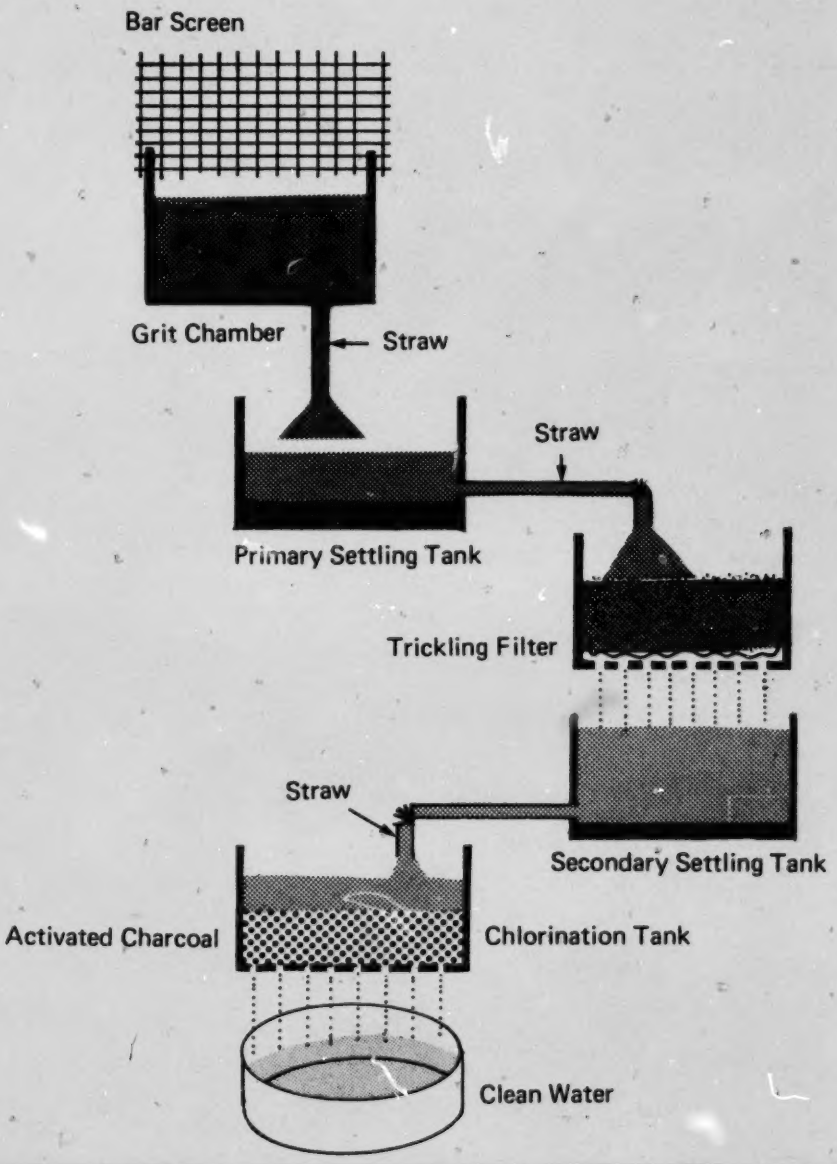
Activity Card 6 – Carbon Absorption

This activity is a visual demonstration of the principle behind carbon absorption, lest the students think that water which contains dissolved organic material takes several days to absorb the organics. In actual practice, the absorption is carried on much faster. The use of methylene blue here is to provide visual evidence of absorption. This activity is relevant for use after the tertiary treatment/aquarium filter analogy has been made.

Activity Card 7 – Constructing A Tertiary Sewage Treatment Plant

The student's instructions here are deliberately sketchy. This allows for creativity on the part of the students who elect this activity. You might suggest that a model of such a plant be set up in your classroom and its operation demonstrated by its designer. This activity should be used after the tertiary overhead transparency has been shown.

TERTIARY SEWAGE TREATMENT, A TYPICAL STUDENT MODEL



SECTION V PROTECTION: IT'S EVERYBODY'S JOB!

FOCUS

The students will revisit Riverview and try to remedy some of the problems there through role-playing activity. Members of the class will be cast as councilmen and various concerned citizens of Riverview, Leadville, and Grand Falls. These citizens will voice their opinions, the councilmen will draft proposed legislation, and then the voting population of Riverview will select the pollution solution that the community wants.

Later in this section, the assignment "Investigating Your Own Community," which was introduced in Section II, will be due. Each student or student group will report their findings on the availability and quality of water in your locale. The information gathered about your own community will be easier to understand and evaluate, once your students have acquired insight concerning water pollution causes, effects, and prevention.

This section, and the entire unit, culminates with emphasis on the role of the individual. When the students are conscious of the problems in their own locale, they can be expected to ask, "What can I do?"

The booklet article entitled, "The Role of the Individual," attempts to answer that question by providing suggested activities through which they, as concerned citizens, can do their part.

THE MATERIALS PROVIDED

Student Booklet	Audio-Visual Materials	Ecomaster Activities	Extension Activities
The Role of the Individual		Worksheet 9 The Riverview Hearing	Activity Card 8 Phosphate Content Survey

MAKING THE MATERIALS WORK, SUGGESTIONS FOR THE TEACHER

Worksheet 9 — The Riverview Hearing

Role playing can be a worthwhile learning experience as well as fun for the students. By role playing a student can directly develop significant attitudes and ideas of his own and gain insight into the attitudes and ideas of other people. The outcome of some experiments and activities may be predictable; role playing is not. No one, neither the students nor you, will be able to foresee the exact outcome of this exercise.

The mayor of Riverview, who probably should be thoughtfully chosen, and the town council have received petitions from the Riv-ecologists (a local ecology group) asking that something be done to correct the growing water pollution in Riverview. They have decided to hold an Open Meeting to hear the citizens' arguments and then draft legislation to correct the problem.

The teacher should see that care is taken in making suitable role assignments. The students who do not or will not take part will become members of the gallery. Instruct them to evaluate as they observe,

because whatever pollution solution is adopted by community vote will affect them as the citizens of Riverview.

In order to give this exercise some direction, it is suggested that each role-playing member of the class be briefed on his goals. These goals should be foremost in his thoughts as he plans for and then delivers his materials and again as he casts his ballot.

Role	Goal	Registered Voter
Mayor	Keep taxes low—spring election	Yes
Councilman 1	Keep taxes low—running for State Senate in fall	Yes
Councilman 2	Keep taxes low—running for Mayor in spring	Yes
Councilman 3	Not worried about taxes—cannot be elected again	Yes
Councilman 4	Not worried about taxes—cannot be elected again	Yes
Riverview Businessman	Expand business	Yes
Riverview Permanent Resident	Low taxes and a clean town and river	Yes
Riverview Summer Resident	Clean river and town	No-nonresident
Leadville Resident	Stop blaming my town	No-nonresident
Grand Falls Resident	Clean river to keep my taxes low	No-nonresident
North Bank Industrial Complex Manager	Expand industrial complex to South Bank	No-nonresident
President of Riv-ecologists	Clean river	Yes
President of RRJHS Ecology Club	Clean river	No-too young
Official from Riverview Board of Health	River could use some cleanup but we still have well water	Yes

You probably would want to suggest that the students reread the Riverview materials in their booklets to reacquaint themselves both with the water quality problems and the community attitudes existing there. Each student should receive his role a day before the meeting. The homework assignment for that night will be to prepare his argument for the meeting.

After the meeting, the homework assignment for each councilman will be to draft a bill for the voting which will take place the next day. As he writes the bill, he should refer to the notes he has taken. He should always keep his goals (his own vested interests) in mind.

The mayor will be in charge. He will call the meeting to order and dispense with the reading of the minutes, committee reports, and old business. He explains to the townspeople and visitors why he has called the meeting, and that they will be

expected to vote on one of four bills drafted by the councilmen.

Allow each speaker from the floor 3 minutes to explain his views to the council. Each speaker must first state his name and address before starting. If there is time and if you wish, you might also encourage students without assigned roles to express their views.

Before you adjourn the meeting, give the councilmen their instructions: that is, to compose one bill each to help correct the problems in Riverview.

The next day, have the councilmen write their proposed bills on the chalkboard. Give the voting citizens of Riverview a chance to read each bill and then cast their ballots. After the ballots have been counted and the new law selected, have the councilmen relate to the class what thoughts went through their heads as they composed their bills. You may also ask the citizens of Riverview to explain why they voted for the bill they did vote for. The mayor is entitled to comment on the bills proposed and the new law.

Worksheet 7 – The assignment given in Section II should now be due. Have each student or group of students report on their part of Worksheet 7 in the sequence in which the assignments occur on the worksheet. Have every student take notes as each report is given.

Items 1 through 3 relate to the water availability in your area. Students will report on the source, the quality, and the quantity of the local water supply.

Items 4 through 6 will tell the class if there is any water pollution in your area. If there are signs of pollution, the class will find out what they are, and if the polluted areas are near industrial, residential, or recreational areas.

Items 7 through 8 are concerned with waste water treatment in your community. Reports will be given on what type of water treatment is available, how large the operation is, how adequate the treatment is, what problems may exist, and whether local industries treat their own wastes or use the city's treatment plant.

Items 9 through 10 deal with water pollution prevention in your area. Students will report on land use regulations, plans for treatment facilities being enlarged or expanded, how citizens feel about water pollution prevention, and what they are doing about it.

After the reports are in, have the students determine whether a problem in water pollution, sewage treatment, zoning, or water availability exists. Have the students think of ways the problem might be solved. You may also want to have the students prepare model legislation (as in the Riverview Hearing). Inform the proper authorities of the students' study, findings, and suggested solutions.

Suggesting action to the city fathers is only one thing a concerned citizen of a community might do to correct water pollution problems. The culminating activity of this unit concerns other ways that people can work for clean water.

Booklet Article 7 – The Role of the Individual

This article suggests levels of commitment for people who want to help work for clean water. Suggested actions range from joining activist groups to observing convenient daily practices in the home.

1. **JOIN** ecology and nature groups. These groups are always looking for people who want to do something for the environment. Their publications serve to keep people informed on what has been done, what is being done, and what might be done to preserve the environment. Many groups have drives and campaigns for specific projects. These campaigns may involve writing to representatives, attending demonstrations, or contributing donations. Many of these groups use dues to maintain a lobby in Washington, D. C. to influence federal legislators. Some suggested groups are these:

Izaak Walton League
1326 Waukegan Road
Glenview, Illinois 60025

Sierra Club
1050 Mills Tower
San Francisco, California 94104

Natural Resources Defense Council
15 West 44th Street
New York, New York 10036

National Audubon Society
950 Third Avenue
New York, New York 10022

League Of Women Voters Of The United States
1730 M Street, N. W.
Washington, D. C. 20036

For a complete listing of organizations in this field, you might consult the *Conservation Directory*. This is published annually by the National Wildlife Federation, 1412 Sixteenth Street, N. W., Washington, D. C. 20036; $1.50 a copy. It is a useful guide for finding allies.

2. **LEARN** what the Federal government has been, is, and will be doing to correct water pollution. You may wish to write to:

Federal Water Pollution Control Administration
Department of the Interior
633 Indiana Avenue, N. W.
Washington, D. C. 20240

Environmental Protection Agency
Waterside Mall
4th & M Streets, S. W.
Washington, D. C. 20460

3. **PRACTICE** water pollution prevention and water conservation yourself. Water pollution prevention is everyone's job. People should be willing to alter their behavior in order to help maintain healthy waterways. The students might be interested to learn that they have the right to report suspected pollutors to local health agencies. They will learn that they also should follow up on such a report to determine that satisfactory action has been taken.

Activity Card 8 – Phosphate Content Survey

In the booklet article "The Role of the Individual," it is suggested that people should use soap and detergents with low phosphate contents. This activity is for a student who might be interested in reporting the "good guy" and "bad guy" cleaning products to his classmates and family. Mention the card when your students are discussing phosphates in their booklet article.

KIT INVENTORY FOR PROTECTING OUR WATER SUPPLIES

1 Teacher's Guide
30 Student Resource Booklets
11 Ecomasters (9 Activities and the 2-page Unit Test)
4 Overhead Transparencies
3 Blank Overhead Transparencies
8 Activity Cards
2 Filmstrips
1 Audio Cassette (recorded on Side A and Side B)

ANSWERS TO THE UNIT TEST

1. b	6. c	11. c	16. c
2. d	7. b	12. b	17. c
3. d	8. d	13. d	18. b
4. d	9. a	14. b	19. a
5. c	10. b	15. a	20. d

SECTIONS OF THE UNIT	STUDENT RESOURCE BOOKLET	COMPONENTS TO COORDINATE WITH RESOURCE BOOKLET		
		Audio-Visual Materials	Ecomaster Activities	Extension Activities
Water Use and Abuse	**Preface to the Unit**	**Filmstrip 1** Water, The Abused Servant of Man **Audio Cassette, Side A** **Overhead Transparency** Water Use	**Worksheet 1** The Effect of Phosphates and Nitrates on Pond Algae **Worksheet 2** How Microorganisms in Water React to Soaps and Detergents **Worksheet 3** The Effect of Sewage on Microorganisms	**Activity Card 1** Water Use in the Home
Pollution: Causes and Some Effects	**Riverview**		**Worksheet 4** Water Pollution Inquiry Questions **Worksheet 5** Water Pollution Inquiry Answer Sheet **Worksheet 6** Analyzing Riverview **Worksheet 7** Investigating Your Own Community	**Activity Card 2** Water Pollution Opinion Poll
Pollution: Interpreting Your Experiments	**A Healthy Waterway** **An Unhealthy Waterway**	**Blank Overhead Transparencies** **Overhead Transparencies** Life in a Healthy Waterway Life in an Unhealthy Waterway		**Activity Card 3** Water-borne Diseases **Activity Card 4** Succession on a Microscope Slide **Activity Card 5** The Effect of Dissolved Salt on Aquatic Plants
Protection: Technology at Work	**Cleanup Technology** **Effects of Certain Other Pollutants** **Lake Tahoe**	**Overhead Transparency** An Ideal Tertiary Sewage Treatment Plant **Filmstrip 2** Lake Tahoe– Then and Now **Audio Cassette, Side B**	**Worksheet 8** Removing Phosphates from Sewage Water	**Activity Card 6** Carbon Absorption **Activity Card 7** Constructing a Tertiary Sewage Treatment Plant
Protection: It's Everybody's Job!	**The Role of the Individual**		**Worksheet 9** The Riverview Hearing	**Activity Card 8** Phosphate Content Survey